RETURNED SIGNAL FROM SPHERE COVERED WITH RETROREFLECTORS ILLUMINATED WITH LASER LIGHT

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A future Mars mission will return a sample of Martian soil to Earth
for further analysis. In one mission concept, the sample will be
placed in a softball-size spherical container, and sent into orbit
around Mars. A rendezvous spacecraft will then capture the container
and return it to Earth.

Coarse, long range location of the sample container will be
accomplished using a solar-powered radio beacon. However, final detection
and orbit maneuvers will require position knowledge beyond the capabilities
of the radio beacon scheme. Accordingly, a laser radar is baselined as
the close-approach rendezvous sensor. To increase the laser radar's signal
return, retroreflectors will be placed on the surface of the sample container
in spaces not occupied by solar cells. In addition to improved accuracy
at short range, a second advantage of the laser radar is that it will
continue to operate during the 40% of each orbit when the radio beacon
is not powered because the sun is occluded by Mars.

This work focuses on the placement of the retroreflectors to
improve the chance of detection. In particular, the number, distribution,
and orientation of the retros must assure coverage of the entire 4 pi
solid angle. Such coverage essentially demands that, for some set of
orientations, more than one retro will contribute to the laser radar
return signal. If the laser light is coherent, these multiple returns
will give rise to interference effects. Small changes in the relative
position and orientation of the sample canister with respect to the
laser radar may produce large variations in the returned
signal. To increase the probability of quickly locating the container,
the retroreflectors must be placed so as to maximize the minimum signal
returned in any orientation. The placement problem is complicated since
the locations of the retroreflectors are limited to areas not occupied by
solar cells, radio antennae, etc. The methodology used to optimize the
return under these constraints is discussed.

Our approach to identifying optimal retro configurations relies heavily
on computer simulations. A plausible retro configuration, constrained
by predefined locations of solar cells, radio antennas, etc. is identified.
We then simulate the complex electromagnetic field from individual
retroreflectors, taking into account variables such as distance, shape
of the retroreflector aperture, observation angle, and Gaussian beam profile.
These individual fields are summed to produce the final interference pattern.

We present simulations of the interference pattern from a promising
retro configuration with illustrations.
Monte Carlo simulations of the distribution of the returned signal are
also shown. A physical model of the sample container with retroreflectors
has also been constructed. The returned signal from this model has been
determined experimentally. Results of the experiments are compared
to the simulations.